# POINTS OF GEOLOGIC INTEREST FOR CRATERS OF THE MOON NATIONAL MONUMENT AND PRESERVE

**All coordinates are in UTM Zone 12, North American Datum 1983**

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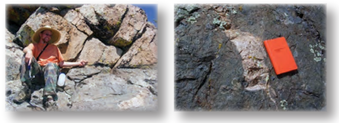
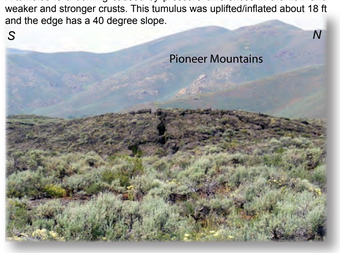
**1 Graded vesicles** *N 4814974 E 289346*
Vesicles form as gasses come out of solution as a result of reduced pressures found near the surface. Density of vesicles is usually greatest near the surface and decreases with depth as illustrated in the left photo. Core from the Grassy Cone Flow (fe1p, right photo) represents two different pulses of lava with an abundance of vesicles at the top of each pulse.

**2 Insitu contact between biotite granite and leucogranite** *N 4815039 E 289778*
This outcrop shows the contact between a leucogranite dike and the Biotite Granite of Cottonwood Creek (Tg, left picture); also note the presence of xenoliths (right picture).



**3 Out of place boulders containing the contact between biotite granite and leucogranite dike** *N 4814859 E 2900014*
On the Grassy Cone Flow (fe1p), a string of light colored rocks are conspicuous from a great distance. These boulders are Challis Age Intrusives from the nearby edge of the Pioneer Mountains. The boulders were placed to block an old road.

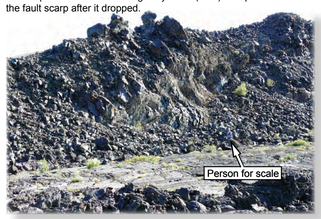
**4 Tumulus** *N 4813109 E 288586*
A tumulus is a doming caused by pressure differences in the flow and weaker and stronger crusts. This tumulus was uplifted/inflated about 18 ft and the edge has a 40 degree slope.




**5 Inflation pit** *N 4812904 E 288381*
From the highway, the surface of the Grassy Cone flow (fe1p) appears relatively flat, however, there are many tumuli and deep inflation pits. Inflation pits often occur when a flow surrounds an old topographic high and chills. As the flow continues to inflate it steps back from the solidified edge and continues to rise. With continued surges and pulses it may step back and continue to inflate multiple times (this pit shows 23 m of inflation).

**6 Platy jointing** *N 4814942 E 292154* and *N 4814965 E 292127*
Platy jointing in the Highway flow (fa8b) visible here is a result of its high silica content causing it to be extremely viscous and creating internal shear when forced to flow up against the flank of South Highway Cone (ca4sh) before the South Highway Fault formed.

**7 Overlook** *N 4815035 E 292352*
When you reach the coordinates the steep drop-off or scarp in front of you is the South Highway Fault. Look for drapery features where still molten parts of the coeval Highway Flow (fa8b) drooped/oozed over the fault scarp after it dropped.



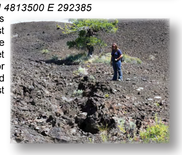

**8 Monoliths** *N 4914915 E 292817*
The monoliths have been interpreted in two different ways: (1) Rafted blocks, pieces of crater walls carried off much like an iceberg by a lava flow or (2) Volcanic necks, cooled conduits for a now missing cone (current map). Note: Off-trail travel is prohibited along the North Crater Flow Trail.

**9 Squeeze-ups** *N 4814581 E 292861*
If pressure is sufficient, lava can rise up through the tension fracture typically found in the top of a flow ridge/pressure ridge/elongate tumulus and squeeze out onto the surface and flow down the sides.

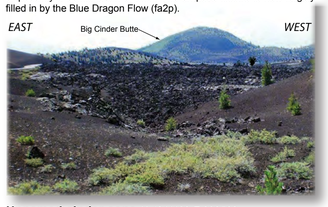

**10 Pumice xenoliths** *N 4814207 E 292380*
Pumice xenoliths found along the North Crater trail may be derived from rhyolites deposited when the Yellowstone Hotspot was beneath Craters of the Moon, or may be related to Eocene volcanics and intrusives, or to the Mississippian Copper Basin Formation (Mcb) or some combination. These xenoliths show that basaltic magma was interacting with the country rock and alludes to the assimilation of pre-existing rocks that subsequently increased the silica content of the basalts here compared to flows in the rest of the plain; also note that basalt is strung through many of the pumice fragments.

**11 Granulite xenoliths** *N 4814141 E 292369*
Granulite xenolith as seen here, was brought up from the lower crust and is Archean in age (~3.4 Ga).


**12 Non-eruptive fissures** *N 4813500 E 292385*
A series of non-eruptive fissures have been identified on the west side of Big Craters (ca5). These fissures are parallel to, but offset from, the main eruptive vents for Big Craters. The longest and most prominent fissure is at least 25 m long.



**13 Inferno cone vent** *N 4813146 E 293206*
The vent for Inferno Cone (c1) lies between the loop road and the spatter cones. The vast majority of the cone was deposited north of the vent because of strong winds, an obstructed vent producing a nozzle effect, or possibly a combination of both. The eruptive fissure is now largely filled in by the Blue Dragon Flow (fa2p).




**14 Unnamed cinder cone** *N 4811182 E 293568*
This small cinder cone is interpreted to be ~6 Ka and is in line with the vents of Big Cinder Butte (cc3) and Silent Cone (cd1). Like many of the cinder cones in the park, it is asymmetrical, elongated to the northeast by prevailing winds during formation.


**15 Granulite xenolith** *N 4810883 E 293274*
A banded piece of granulite is embedded in one of the large rafted blocks near the Tree Molds trail. This golf ball size xenolith of Archean age lower crust was brought to the surface by basaltic magma, deposited in Big Cinder Butte (cc3), and finally carried off within the rafted block by the Sawtooth Northwest Flow (fc3) to its current position.

**16 Hornitos** *N 4810843 E 292980*
Hornitos (rootless vents) are the tube-fed counterpart of spatter cones. In contrast spatter cones (rooted vents) are fed directly by the eruptive fissure. Both are formed from globs of lava ejected short distances onto the surface forming short steep- sided cones. There is both a larger ("Momma") and a smaller ("Baby") hornito at this location.


**17 Blue Dragon flow glaze** *a: N 4810542 E 293300, b: N 4809627 E 292918, c: N 4809473 E 292770*
The Blue Dragon Flow (fa2) has a ubiquitous blue glass present on its surface. The color is believed to either be caused by titanium in the magnetite or is equivalent to a ceramic glaze. Which hypothesis is correct is yet to be determined.

**18 Natural bridge** *N 4810446 E 293165*
Natural bridges are found throughout the Craters of the Moon lava field and most formed from lava tube collapse, the bridge being a remnant of tube ceiling. This small natural bridge can be seen from the Tree Molds trail.

**19 Breadcrust bomb** *N 4810250 E 293189*
Volcanic bombs begin as globs of lava erupted high into the air. In the case of the breadcrust bomb seen here, an initial crust formed that was cracked as gases inside continued to expand, much l ke bread rising in the oven does, hence the name.

**20 Tree molds** *N 4810083 E 293101, N 48109762 E 292965*
Tree molds form when a tree is surrounded by lava. As the lava wraps around the tree, it cools and hardens while the tree smolders and burns away, leaving a cylindrical mold of the charred trunk and branches. Molds can be vertical if the tree managed to stay upright or may be horizontal if the tree was bulldozed over.


**21 Water hole** *N 4811315 E 294495*
This waterhole lies inside the drained central portion of an old lava pond rimmed by levees. The pond formed above the main tube system for the Blue Dragon Flow (fa2), but before it completely solidified the interior of the pond drained back into the tube system. The waterhole represents a perched water table over ice. A rock cairn on the levee marks its location.

**22 Shelly pahoehoe** *N 4811820 E 294758*
The thin crusts, blisters, and small open tubes of this shelly pahoehoe formed as a near vent deposit (just a few hundred feet from the vent), where the lava was still very hot, fluid, and gas charged. Thickness of the shells ranges from 7-30 cm.

**23 Small kipukas** *N 4810955 E 293998*
A kipuka is an older area surrounded by a younger lava flow making the older landscape an island within it. These two small kipukas (A, & B), seen at the northern base of Big Cinder, are made up of the Sawtooth NW flow (fc3) and rafted blocks of Big Cinder (fc3r) that were carried and surrounded the 4,000 year younger Broken Top flow (fa1).


**24 Broken Top fissures** *N 4811401 E 294340*
The fissures seen here are interpreted to be part of the Trench Mortar Flat event, making the cone older than 2.2 Ka. For further discussion see current interpretation on map sheet.


**25 Tilted southeast flanks** *N 4811315 E 294495*
After an eruption hiatus between the original formation of the Broken Top cone (ca1), re-inflation of the cone and subsequent outpouring of the Broken Top Flow (fa1) tilted up these small flank eruptions that vesiculation indicates were originally laid down close to horizontal.


**26 Drained tumulus** *N 4811232 E 294415*
A tumulus is a doming caused by pressure differences in the flow and weaker and stronger crusts. After forming, this one managed to drain leaving a bell shaped void within.

**27 Gravity faults** *N 4810852 E 294551*
These gravity faults are the result of slopes being in excess of the normal angle of repose for a cinder cone (~30°), resulting in slope failure.

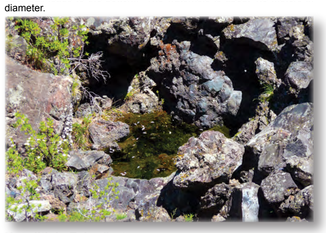

**28 Granulite xenolith** *N 4810732 E 294520*
Xenoliths are fragments of pre-existing older rocks ripped loose and transported to the surface during volcanic eruptions. This xenolith is a granulite and represents lower crustal rocks of Archean Age (>3 Ga).


**29 Tree molds** *N 4809529 E 295624*
Tree molds can form when lava flows around or bulldozes down a tree. Before the tree is consumed by fire the lava solidifies, leaving a cylindrical mold of the tree and/or a tire track like pattern of charred wood preserved in the lava. Molds can preserve the outline and position of trunks, limbs and root structures. The tree mold in the top photo is 2.2 m deep, 0.9 meters in diameter, and preserves the position of nine limbs. The lower photo shows tree molds from which the direction of lava flow can be determined; the lava wrapped around the trunks of the trees, freezing and accumulating on the up-stream side of the flow.

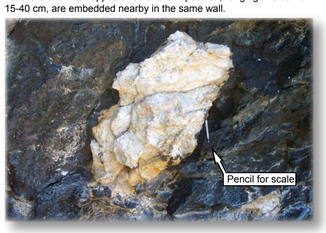
**30 Trench Mortar Flat crater vents** *N 4808668 E 296703*
A well defined system of crater vents lies between the two Trench Mortar Flat cinder mounds (ca3), SW of Crescent Butte (ch1). There are six craters of similar size that align along the Great Rift. The average crater length and width is 65 and 40 meters respectively. The craters span approximately 0.5 km along the Great Rift. Walls of agglutinated spatter outline the depresssions. Large boulders of failed spatter wall lie inside most of the craters.


**31 Tree mold** *N 4808520 E 297042*
This tree mold is 4.4 m deep and 0.38 m wide and may be the deepest tree mold in the park.

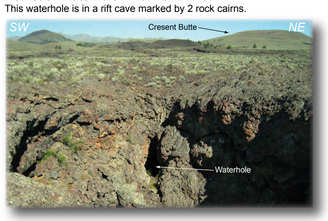
**32 Yellowjacket waterhole** *N 4808356 E 297064*
This waterhole is found at the bottom of the second large crater vent south of the Trench Mortar Flat cinder mounds (ca3). A roughly defined deer trail leads to the bottom. The waterhole is about 1.5 meters in diameter.



**33 Xenolith in Echo Crater** *N 480786 E 296840*
A large white granulite xenolith is embedded in the south wall of Echo Crater. The xenolith is about 1 m long by 0.5 m wide. Several other xenoliths of similar appearance and composition, ranging in size from 15-40 cm, are embedded nearby in the same wall.




**34 Bearsden waterhole** *N 4807734 E 297564*
This waterhole is in a rift cave marked by 2 rock cairns.




**35 Tree mold** *N 4807542 E 297592*
Located between Bearsden and Little Prairie waterholes, this tree mold is 2.9 m deep and 0.45 m wide and preserves the position of 3 limbs.

**36 Little Prairie waterhole** *N 4807500 E 297812*
This waterhole is in the volcanic rift. The two logs were placed across the rift to form a bridge which allowed a bucket to be lowered into the water and emptied into the old concrete sheep trough near it.


**37 Noneruptive fissures** *N 4807163 E 297858*
Southernmost segment of noneruptive fissures associated with the 2.2 Ka Trench Mortal Flat Event.




**38 Watchman flank vents** *N 4806571 E 298349*
Watchman cinder cone formed during the Trench Mortar Flat eruption about 2.2 Ka and exhibits some of the best examples of flank eruptions in the park. The north slope of Watchman produced a pahoehoe flow (fa3p), and the south slope produced a slabby pahoehoe (slab-lava) flow (fa3s). The uppermost point of each flow features a shallow valley or rift with small spatter ramparts on each side. The south vent spatter ramparts are partially composed of tachylytic material.